AF/2152/ IFW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

APPELLANTS:	Birkhoelzer et al.	CONFIRMATION NO. 7671
SERIAL NO.:	09/992,974	GROUP ART UNIT: 2152
FILED:	November 19, 2001	EXAMINER: Ramsey Rafai
TITLE:	"MEDICAL SYSTEM ARCHITECTURE WITH A WORKSTATION AND A CALL SYSTEM"	

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APPELLANT'S APPEAL BRIEF

S I R:

Pursuant to 37 C.F.R. §41.37, Appellants herewith submit their main brief in support of the appeal of the above-referenced application.

REAL PARTY IN INTEREST:

The real party in interest is the assignee of the present application, Siemens Aktiengesellschaft, a German corporation.

RELATED APPEALS AND INTERFERENCES:

There are no related appeals and no related interferences.

STATUS OF CLAIMS:

Claims 1-22 are the subject of the present appeal, and constitute all pending claims of the application. No claims were added or cancelled during prosecution before the Examiner.

STATUS OF AMENDMENTS:

Amendment "C" was filed following the Final Rejection on January 17, 2006. In the Final Rejection, claim 1 was rejected under §112, second paragraph because the Examiner noted the terms "said examination images" and "said medical images"

used in claim 1 lacked antecedent basis. In Amendment "C", Appellants amended claim 1 to use the term "medical examination images" consistently throughout that claim (and claim 13 was amended in the identical manner).

In an Advisory Action dated January 2, 2006, it was stated that this Amendment would not be entered because the Examiner stated the amended claims contained features not previously presented and would require further search and consideration by the Examiner.

Appellants filed a Petition on February 14, 2006 to have Amendment "C" entered, based on Appellants' belief that Amendment "C" did no more than editorially amend the claims, and moreover those amendments were made in direct response to the aforementioned rejection under §112, second paragraph. In another Advisory Action dated March 9, 2006, Appellants' Petition was denied.

Attached to Amendment "C" were four patents submitted by the Appellants as evidence to rebut a citation to two other patents that the Examiner made for the first time in the Final Rejection, in support of the Examiner's interpretation of a term in the claims. Appellants therefore filed Applicants' Response Under 37 C.F.R.§1.116 on March 29, 2006 wherein the aforementioned four patents were resubmitted, and no claim amendments were made, so that these patents could be made a part of the prosecution record, and therefore relied upon in the present Brief. As of the filing of the present Brief, the Examiner has not yet had the opportunity to rule on the entry of Applicants' Response Under 37 C.F.R.§1.116. Since it would be extremely unfair for the Examiner to cite patents as evidence (not relied on to formulate a prior art rejection) for the first time in the Final Rejection, and then to deny the Appellants the opportunity to submit counter-evidence, Appellants have assumed that Applicants'

Response Under 37 C.F.R.§1.116 will be entered, and have relied on the counter-evidentiary patents herein (Attachments A, B. C and D).

SUMMARY OF CLAIMED SUBJECT MATTER:

he claims on appeal concern a medical system architecture of the type initially described wherein call system linked into the medical workflow for the transmission of messages, for example as datafiles, is allocated to at least one of the workstations. The user of a medical workstation, for example a modality, can send digital messages to an expert in an electronic manner proceeding from the console of the workstation. The medical modalities can be, for example, an MR, CT, ultrasound, X-ray or angiography device, a nuclear camera, supervision monitor, diagnostic workstation or irradiation apparatus. An automated expert call system to a mobile communication device proceeding from a workstation is thus obtained that is integrated into the work and data context of the medical workstation. Due to the combination of the workstation with a call system, a completely new application scenario arises wherein the radiologist — as an expert — is available by retrieval. This application scenario has not been realizable with the previous means (for example, image transfer to workstations). (p.2, l.22 -p.3, l.11)

Figure 1 shows the system architecture of a hospital network as an example. The modalities 1 through 4 serve for the acquisition of medical images; these can be, for example, a CT unit 1 for computed tomography, an MR unit 2 for magnetic resonance imaging, a DSA unit 3 for digital subtraction angiography and an X-ray unit 4 for digital radiography 4 as image-generating systems. (p.5, l.4-8) Operator consoles (workstations) 5 through 8 of the modalities are connected to these

modalities, the acquired medical images being processed and locally stored therewith. Patient data belonging to the images also can be entered. (p.5, l.8-11)

For linking to a PACS, the operator consoles 5 through 8 are connected to a communication network 9, such a LAN/WAN backbone for distributing the generated images and for communication. (p.5, l.12-14) Thus, for example, the images generated in the modalities 1 through 4 and the images that are further-processed in the operator consoles 5 through 8 can be stored in a central image storage and image archiving system 10 or can be forwarded to other workstations. (p.5, l.14-17)

Further viewing workstation represented by a workstation 11 are connected to the communication network 9 as diagnostics consoles that have local image memories. For example, such a viewing workstation 11 is a very fast mini computer on the basis of one or more fast processors. (p.5, l.18-21) The images that are acquired and deposited in the image archiving system can be subsequently called in the viewing workstation 11 for diagnosis and can be deposited in the local image memory, from which they can be immediately available to the diagnostician working at the viewing workstation 11. (p.5, l.21-24)

Further, servers 12, for example patient data servers (PDS), file servers, program servers and/or EPR servers, are connected to the communication network 9. (p.6, l.1-2)

The image and data exchange via the communication network 9 ensues according to the DICOM standard, an industry standard for the transmission of images and further medical information between computers, so that a digital communication between diagnosis and therapy devices of different manufacturers is possible. (p.6, l.3-6) A network interface 13 via which the internal communication

network 9 is connected to a global data network, for example the world wide web, can be connected to the communication network 9, so that the standardized data can be exchanged with different networks world-wide. (p.6, l.6-10)

A communication server 14 that coordinates the sending and the reception of the messages is connected to the communication network 9. A communication system 15, for example a transmitter that transmits the messages to a communication device (not shown in Figure 1) is connected to the communication server 14. The communication system 15 can be a radio transmitter, a number of infrared transmitters or, for example, more complex components of a mobile radiotelephone network. (p.6, l.1-2)

Figure 2 shows a workstation 16 of an operator console 5 through 8 of one of the modalities 1 through 4 or of a viewing workstation 11, for example the operator console 6 of the MR unit 2. (p.6, l.17-19) A communication window 18, which shall be described in greater detail with reference to Figure 3, is mixed in on the monitor 17 of the workstation 16 as a user front end. (p.6, l.19-21) The message that can be entered in this communication window 18 is transmitted, for example as a datafile, to a communication service 19 that can be composed of the communication server 14 and the communication system 15. (p.6, l.21-23) This communication service routes the message to a mobile communication device 20 that, for example, can be a WAP cell phone, SMS cell phone or a beeper with display. (p.6, l. 23-p.7, l.2)

Figure 3 shows the user interface 21 of the monitor 17 of the operator console 6 of the MR unit 2. An image processing window with a number of juxtaposed MR exposures is reproduced on the user interface 21, a control region 23 with icons for

triggering commands being arranged next to this in a known way for operation. (p.7, l.3-6)

When an expert is to be notified proceeding from the MR operator console 6 because a question or a problem arises during the examination or during the post-processing, then the communication window 18 can be opened on the user interface 21 of the operator console 6 of the MR unit 2 by clicking on the icon 24. (p.7, l.3-6)

An input field 25 for the expert to be called is arranged in the communication window 18, this, for example, being pre-occupied by the name of the attending physician from the electronic patient record (EPR). The patient can be entered into a further name field 26, whereby the name of the patient is pre-occupied from the patient present at the operator console 6. (p.7, l.11-15) An input field 27 for the procedure, pre-occupied from the current examination, can likewise be edited. The problem and the urgency can be briefly explained in a text field 28, so that the expert can react or reply immediately. (p.7, l.15-17) By pressing the "send" button, the message is transmitted as datafile via the communication server 14 to the transmitter 15 and is then forwarded to the communication device 20 by radio or infrared light. (p.7, l.18-20)

By clicking an audio icon 29, a voice input can ensue with a microphone (not shown), the voice input being communicated to the communication device 20 as audio datafile and being emitted thereat. (p.7, l.21-23)

The call system also can have an information return channel 30 (shown in Figure 2) from the communication device 20 to the workstation 16 via which the communication device 20 can send a received confirmation after reading the message. (p.8, l.1-3)

However, an answer to the question asked of the expert also can be communicated either in text form — as a text datafile entered at the communication device 20 and sent to the workstation 16 — or likewise by voice input with audio datafile. (p.8, l.4-6)

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL:

The following issues are presented in the present Appeal:

whether claim 1 is indefinite under 35 U.S.C. §112, second paragraph;

whether the subject matter of claims 1-14 is anticipated under 35 U.S.C. §102(e) by United States Patent No. 6,321,113 (Parker et al.);

whether the subject matter of claim 15 would have been obvious to a person of ordinary skill in the field of medical system architecture design under the provisions of 35 U.S.C. §103(a) based on the teachings of Parker et al. in view of United States Patent No. 6,629,131 (Choi);

whether the subject matter of claims 16-19 and 22 would have been obvious to a person of ordinary skill in the field of medical system architecture design under the provisions of 35 U.S.C. §103(a) based on the teachings of Parker et al., further in view of "Official Notice" of various types of communication software and components;

whether the subject matter of claim 20 would have been obvious to a person of ordinary skill in the field of medical system architecture design under the provisions of 35 U.S.C. §103(a) based on the teachings of Parker et al., further in view of United States Patent No. 6,304,898 (Shiigi); and

whether the subject matter of claim 21 would have been obvious to a person of ordinary skill in the field of medical system architecture design under the

provisions of 35 U.S.C. §103(a) based on the teachings of Parker et al., further in view of United States Patent No. 6,829,478 (Layton et al.).

ARGUMENT:

Rejection of Claim 1 Under §112, Second Paragraph

As noted above, Appellants acknowledge that in claim 1, the terms "examination images" and "medical images" are both used, and there is also a location at which the term "examination image" is used. As also noted above, Appellants attempted to make editorial changes in claim 1 to correct this informality, but the Examiner, for reasons with which Appellants strongly disagree, refused to enter the Amendment, stating it would require further searching or consideration.

Therefore, Appellants cannot deny the use of these different terms in claim 1, but remain willing to make editorial changes in claim 1 to correct this informality, and in fact try to do so in order to avoid the Board of Patent Appeals and Interferences from having to devote time to this trivial and easily correctable item.

Moreover, it is clear that despite the use of these different terms in claim 1, the Examiner has had no difficulty in intelligibly interpreting claim 1, as evidenced by the fact that the Examiner has been able to conduct searching with regard to the content of claim 1 and to apply prior art against the language of claim 1. As the Federal Circuit stated in *Energizer Holdings, Inc.v. Int'l Trade Comm.*, 77 U.S.P.Q.2d 1625 (Fed. Cir. 2005), a lack of antecedent basis in a claim does not require the conclusion that the claim is indefinite under §112, second paragraph as long as the claim is "amenable to construction." Appellants respectfully submit that since the Examiner has been able to conduct searching with regard to claim 1, and has been able to apply prior art references against the language of claim 1, this means that

claim 1 is clearly "amenable to construction." Therefore, even though Appellants are willing to make editorial changes in claim 1 to address the rejection under §112, second paragraph, this does not compel the conclusion that the rejection under §112, second paragraph must be sustained, nor does it preclude the Board of Patent Appeals and Interferences from proceeding to review the prior art rejections.

Federal Circuit precedent therefore exists for reversing the rejection of claim 1 under §112, second paragraph.

Rejection of Claims 1-14 Under 35 U.S.C. §102(e) as being Anticipated by Parker et al.

Claim 1 claims a medical system architecture wherein examination images of an examination subject are acquired with an imaging modality, and are supplied to a workstation that is connected to a system for transmitting the examination images to at least one location that is remote from the workstation. The medical system architecture of claim 1 also requires a call system allocated to the workstation for transmitting messages *together with data representing the medical images* to a remote location. As noted above, Appellants acknowledge that, at all locations in claim 1, the "examination images" are the same as the "medical images."

Appellant's position with regard to all rejections based on the Parker et al. reference is that there is no disclosure in the Parker et al. reference describing the generation or transmission of images in general, nor any disclosure of the transmission of medical images or examination images (both terms being used in claim 1, as noted above). The Parker et al. reference is exclusively concerned with the generation and transmission of text data, possibly combined with a representation of an electrical signal, such as an ECG. Appellants argued that an ECG is simply a trace or a curve, representing a single electrical signal, and does

not represent a medical examination image, as that term is commonly understood by those of ordinary skill in the field of medical imaging.

Such arguments, at page 10 of the Final Rejection (paragraph 40) the Examiner provided citations to two patents that the Examiner considers as supporting a definition of “medical examination image” or “imaging modality” that encompasses the representation of an ECG. Appellants respectfully submit that the Examiner’s reliance on these citations is incorrect.

The Examiner cited the Manning et al. reference (United States Patent No. 6,501,979) as defining “imaging modality” as “any imaging modality that acquires imaging data by a process that can be disturbed by body motions.” Appellants have no disagreement with this definition, however, it is merely a tautology, since it defines “imaging modality” in terms of the acquisition of “imaging data,” and Appellants do not agree that an ECG is considered by those of ordinary skill in the field of medical imaging as “imaging data.” As noted above, an ECG is simply a curve or a trace, and is not an image. This definition, therefore, merely shifts the question of what is an “imaging modality” to the question of what are “imaging data,” and therefore provides no support for the position that an ECG system is an “imaging modality” nor that “imaging data” encompass an ECG (by itself).

The Examiner also cited the Hutson reference (United States Patent No. 5,662,109) as listing “multiple modalities of medical imaging,” among which electrocardiography (ECG) is listed. The Examiner, however, has only partially quoted the sentence in which that phrase occurs in the Hutson reference. The complete sentence begins “The system and method of the present invention correlate *data* from multiple modalities for medical imaging, including... .” This

sentence, therefore, is describing data (without restriction) that can be obtained from any number of imaging modalities, and the listing therefore not only includes the imaging modalities themselves, but also the data that can be acquired therefrom. Appellants acknowledge that an ECG can be *obtained from* an imaging modality, since ECG monitoring and ECG triggering are commonly used in the production of medical images. Simply because an ECG is available from an imaging modality, as being among the total available data from that imaging modality, does not mean that the ECG itself is considered by those of ordinary skill in the field of medical imaging as a "medical image" or an "examination image" as set forth in the claims of the present application. Moreover, it is clear from the drawings of the Hutson reference that the method and system described therein would have no, or extremely little, utility in processing an ECG signal. The drawings clearly indicate that true medical examination images are being processed in the Hutson reference. It is not seen how the techniques shown in Figures 6 through 13 of the Hutson reference, for example, could have any applicability whatsoever to processing an ECG signal. Therefore, it is clear that the complete statement in the Hutson reference, of which the Examiner cited only a portion, includes electrocardiography in the listing not as an example of a medical image, but as an example of data that can be acquired, *in addition to medical images*, from an imaging modality.

Numerous standard texts and dictionaries support the position of the Appellants that the term "medical examination image" is not considered by those of ordinary skill in the field of medical imaging to encompass an ECG.

Attached hereto as Attachment "A" is a printout from the online encyclopedia *Wikopedia*, describing medical imaging in general. As can be seen from that

excerpt, a number of categories of medical imaging are listed, none of which mentions ECG, even as an augmentation. Moreover, the online article provides a number of links to other articles in the encyclopedia, and none of these links is to any other section of the online encyclopedia that is directed to electrocardiography. Therefore, not only is there no reference to electrocardiography, as an example of medical imaging, in the article itself, but the authors obviously did not even consider electrocardiography as being sufficiently related to medical imaging to include it in any of the links.

Attached hereto as Attachment "B" is an excerpt from the *McGraw-Hill Dictionary of Scientific and Technical Terms*, providing a definition of medical imaging as the production of visual representations of body parts, tissues or organs. This definition clearly does not encompass an ECG, and electrocardiography is not listed as being among the general categories of medical imaging provided in that definition.

Attachment "C" is an excerpt from a standard medical text (*Foundations of Medical Imaging*), and in the introduction, that provides an overview of all types of medical imaging that will treated in the text, a definition is provided in the third full paragraph at page 4, stating that modern or contemporary medical imaging is a two-part process: (1) the collection of data concerning the interaction of some form of radiation with tissue, and (2) the transformation of these data into an image (or a set of images) using specific mathematical methods and computational tools. Clearly an ECG is simply a measurement of an electrical signal, and does not involve the interaction of radiation with a subject. In this regard, it is no different than a curve representing a measurement of blood pressure, temperature, etc., and thus falls into

the category of “sensing” rather than “imaging.” An excerpt from another standard text (*Principles of Medical Imaging”*) Is attached hereto as “Attachment “D”. In the Preface to that textbook, the various categories of medical imaging (imaging modalities) are listed, and clearly ECG is not included.

Appellants respectfully submit that the attachments hereto are highly representative of the meaning that those of ordinary skill in the field of medical imaging ascribe to the term “medical examination images,” and they clearly demonstrate that those of ordinary skill do not ordinarily consider an ECG to fall within that definition.

In the context of the anticipation rejection based on Parker et al., this is not simply a trivial or semantic distinction. The fact that the Parker et al. reference does not provide any *disclosure* whatsoever with regard to acquiring or transmitting medical examination images, as that term is commonly understood by those of ordinary skill in the field of medical imaging, is sufficient to overcome the anticipation rejection of claims 1-14 based on the Parker et al. reference, since the Parker et al. reference does not disclose all of the elements of claim 1 as arranged and operating in that claim. Claims 2-14 add further structure to the novel combination of claim 1, and therefore are not anticipated by Parker et al. for the same reasons.

Rejection of Claim 15 Under 35 U.S.C. §103(a) Based on Parker et al. and Choi.

As to all of the rejections under 35 U.S.C. §103(a) wherein Parker et al. is relied upon as the primary reference, in combination with respective secondary references or “official notice,” the distinction between a “medical examination image” and an ECG is relevant because, in order to substantiate a rejection under 35 U.S.C. §103(a) based on a modification of the Parker et al. reference, the Examiner must

provide evidentiary support for the position that it would have been obvious to a person of ordinary skill in the field of medical imaging to make use of the teachings of Parker et al., which are exclusively directed to the generation and transmission of an ECG, for the purpose of generating and transmitting true "medical examination images." In view of the above evidence showing that those of ordinary skill in the field of medical imaging do not consider an ECG to fall into the category of a "medical examination image," Applicant respectfully submits the Examiner cannot simply conclude, without proper evidentiary support, that there is no difference between the two. Applicants respectfully submit the Examiner has not provided the proper evidentiary support required by numerous decisions of the United States Court of Appeals for the Federal Circuit indicating a motivation, inducement or guidance in any of the references of record to apply the teachings of Parker et al., which are exclusively disclosed in that reference in the context of ECG generation and transmission, to the generation and transmission of "medical examination images." In view of the significant differences between an ECG and a true "medical examination image," Applicants respectfully submit that even if a person of ordinary skill in the field of medical imaging had the insight to apply the ECG-based teachings of Parker et al. to the field of medical imaging, this would be an insight supporting patentability, rather than a basis for negating patentability.

The Federal Circuit stated in *In re Lee* 227 F.3d 1338, 61 U.S.P.Q. 2d 1430 (Fed. Cir. 2002):

> "The factual inquiry whether to combine references must be thorough and searching. ...It must be based on objective evidence of record. This precedent has been reinforced in myriad decisions, and cannot be dispensed with."

Similarly, quoting *C.R. Bard, Inc. v. M3 Systems, Inc.* 157 F.3d 1340, 1352, 48 U.S.P.Q. 2d 1225, 1232 (Fed. Cir. 1998), the Federal Circuit in *Brown & Williamson Tobacco Court v. Philip Morris, Inc.,* 229 F.3d 1120, 1124-1125, 56 U.S.P.Q. 2d 1456, 1459 (Fed. Cir. 2000) stated:

> [A] showing of a suggestion, teaching or motivation to combine the prior art references is an 'essential component of an obviousness holding'.

In *In re Dembiczak,* 175 F.3d 994,999, 50 U.S.P.Q. 2d 1614, 1617 (Fed. Cir. 1999) the Federal Circuit stated:

> Our case law makes clear that the best defense against the subtle but powerful attraction of a hindsight-based obviousness analysis is rigorous application of the requirement for a showing of the teaching or motivation to combine prior art references.

Consistently, in *In re Rouffet,* 149 F.3d 1350, 1359, 47 U.S.P.Q. 2d 1453, 1459 (Fed. Cir. 1998), the Federal Circuit stated:

> [E]ven when the level of skill in the art is high, the Board must identify specifically the principle, known to one of ordinary skill in the art, that suggests the claimed combination. In other words, the Board must explain the reasons one of ordinary skill in the art would have been motivated to select the references and to combine them to render the claimed invention obvious.

In *Winner International Royalty Corp. v. Wang,* 200 F.3d 1340, 1348-1349, 53 U.S.P.Q. 2d 1580, 1586 (Fed. Cir. 2000), the Federal Circuit stated:

> Although a reference need not expressly teach that the disclosure contained therein should be combined with another, ... the showing of combinability, in whatever form, must nevertheless be clear and particular.

Lastly, in *Crown Operations International, Ltd. v. Solutia, Inc.,* 289 F.3d 1367, 1376, 62 U.S.P.Q. 2d 1917 (Fed. Cir. 2002), the Federal Circuit stated:

> There must be a teaching or suggestion within the prior art, within the nature of the problem to be solved, or within the general knowledge of a person of ordinary skill in the field of the invention, to look to particular sources, to select particular elements, and to combine them as combined by the inventor.

For these reasons, even if the Examiner's statements regarding the individual teachings of the Choi reference are accurate, Appellants respectfully submit the Examiner has not satisfied the aforementioned rigorous evidentiary standards for the Examiner's interpretation of the term "medical image" in claim 1, nor as to the alleged guidance, based on teachings in the references themselves, for combining the references in the manner proposed by the Examiner.

Claim 15, therefore, would not have been obvious to a person of ordinary skill in the field of medical system architecture design under the provisions of 35 U.S.C. §103(a), based on the teachings of Parker et al. and Choi.

Rejection of Claims 16-19 and 22 Under 35 U.S.C. §103(a) as being Unpatentable over Parker et al. in View of "Official Notice"

With regard to claim 16, the Examiner took Office Notice that the concept and advantages of using Corba technology is well known, and the Examiner took the same position with regard to Official Notice with respect to the use of instant messaging technology in claim 17, Java Enterprise Beans technology as claim 18, the use of Java Applet in a browser with regard to claim 19 and the use of a beeper with regard to claim 22.

For the same reasons discussed above in connection with the rejection based on Parker et al. and Choi, Appellants respectfully submit that even if the Examiner's conclusions regarding the various items for which Official Notice has been taken are correct, the references still do not provide the rigorous evidentiary support as to

teachings that would guide a person of ordinary skill in the medical architecture technology to combine the known information with the subject matter of claim 1.

<u>Rejection of Claim 20 under 35 U.S.C. §103(a) as Unpatentable over Parker et al. in view of Shiigi</u>

The Examiner has relied on the Shiigi reference as teaching a WAP phone, which the Examiner acknowledges is not taught in the Parker et al. reference. Appellants acknowledge that the Shiigi reference provides such a teaching, however, for the same reasons noted above with regard to the other rejections under 35 U.S.C. §103(a) Appellants respectfully submit the Examiner has failed to satisfy the high standard of evidence required to support the position that either of the Parker et al. or Shiigi references provides teachings, motivations, inducements or guidance to a person of ordinary skill in the field of medical system architecture design, so as to justify a conclusion that it would have been obvious to such a person of ordinary skill to modify the Parker et al. reference in accordance with the disclosure of the Shiigi reference. This is particularly true, as with the other rejections under 35 U.S.C. §103(a), in view of the discussion above regarding the term "medical image" in claim 1 and the lack of a teaching thereof in the Parker et al. reference.

<u>CONCLUSION:</u>

For the foregoing reasons, Appellants respectfully submit the Examiner is in error in law and in fact in rejecting claims 1-22 that are of the subject of the present Appeal. Reversal of those rejections is therefore proper, and the same is respectfully requested.

This Appeal Brief is accompanied by a check for the requisite fee in the amount of $500.00.

Submitted by,

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CERTIFICATE OF MAILING

I hereby certify this correspondence is being deposited with the United States Postal Service as First Class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450 on April 7, 2006.

Steven H. Noll

STEVEN H. NOLL

CLAIMS APPENDIX

1. A medical system architecture comprising:

an imaging modality for acquiring medical examination images of an examination subject;

a workstation selected from the group of workstations consisting of workstations for acquiring said examination images, workstations for sending said examination image, and workstations for receiving said examination images;

a system connected to said workstation for transmitting said medical examination images to at least one location remote from said workstation; and

a call system allocated to said workstation for transmitting messages together with data representing said medical examination images to a remote location.

2. A medical system architecture as claimed in claim 1 wherein said workstation also processes data associated with said examination images, and further comprising a memory connected to said system which stores said data and said examination images in allocated fashion.

3. A medical system architecture as claimed in claim 1 wherein said call system allows manually modifiable entries of auxiliary information to ensue automatically from object types stored in a data bank.

4. A medical system architecture as claimed in claim 1 wherein said call system comprises a user front end, a communication service and a mobile communication device.

5. A medical system architecture as claimed in claim 4 wherein said user front end is integrated in an application at said workstation.

6. A medical system architecture as claimed in claim 4 wherein said communication services comprises a communication server and a communication system.

7. A medical system architecture as claimed in claim 1 wherein said call system allows a manually modifiable entry of a message recipient to ensue automatically in said message.

8. A medical system architecture as claimed in claim 1 wherein said call system allows a manually modifiable entry of a current patient, being examined with said modality, to ensue automatically in said message.

9. A medical system architecture as claimed in claim 1 wherein said call system allows a manually modifiable entry of a current procedure being executed by said modality to ensue automatically in said message.

10. A medical system architecture as claimed in claim 1 wherein said call system allows entry of an arbitrary text as specific auxiliary information in said message.

11. A medical system architecture as claimed in claim 1 wherein said call system comprises a mobile communication device with a display.

12. A medical system architecture as claimed in claim 11 wherein said call system includes a voice input unit at said workstation allowing a voice input to be transmitted to said communication device as an audio data file, and wherein said communication device comprises an audio transducer allowing emission of said voice input at said communication device.

13. A medical system architecture as claimed in claim 1 wherein said workstation has a monitor on which said medical examination images are displayed, and wherein said call system is connected to said workstation to cause a communication window to be overlaid on said examination images at said monitor.

14. A medical system architecture as claimed in claim 1 wherein said call system comprises a mobile communication device with a display and an information return channel from said communication device to said workstation allowing information to be transmitted from said communication device to said workstation.

15. A medical system architecture as claimed in claim 14 wherein said communication device transmits a confirmation of receipt of said message to said workstation after said message has been read at said communication device.

16. A medical system architecture as claimed in claim 1 wherein said call system comprises a user front end, a communication service and a mobile communication device, and wherein said workstation communicates with said communication service via Corba technology.

17. A medical system architecture as claimed in claim 1 wherein said call system comprises a user front end, a communication service and a mobile communication device, and wherein said workstation communicates with said communication service via Instant Messaging technology.

18. A medical system architecture as claimed in claim 1 wherein said call system comprises a user front end, a communication service and a mobile communication device, and wherein said workstation communicates with said communication service via Java Enterprise Beans technology.

19. A medical system architecture as claimed in claim 1 wherein said call system comprises a user front end, a communication service and a mobile communication device, and wherein said user front end comprises a Java applet in a browser.

20. A medical system architecture as claimed in claim 1 wherein said call system comprises a user front end, a communication service and a WAP cell phone.

21. A medical system architecture as claimed in claim 1 wherein said call system comprises a user front end, a communication service and a SMS cell phone.

22. A medical system architecture as claimed in claim 1 wherein said call system comprises a user front end, a communication service and a beeper with a display.

RELATED APPEALS AND INTERFERENCES

None.

EVIDENCE APPENDIX

Attachments A, B, C and D were submitted with Appellants' Response under 37 C.F.R.§1.116 filed by Certificate of Mailing on March 29, 2006. That response was filed after the Final Rejection, and included a request for entry thereof under 37 C.F.R.§1.116. As of the date of mailing of this Appeal Brief, an indication of entry or non-entry of that Response has not been received.

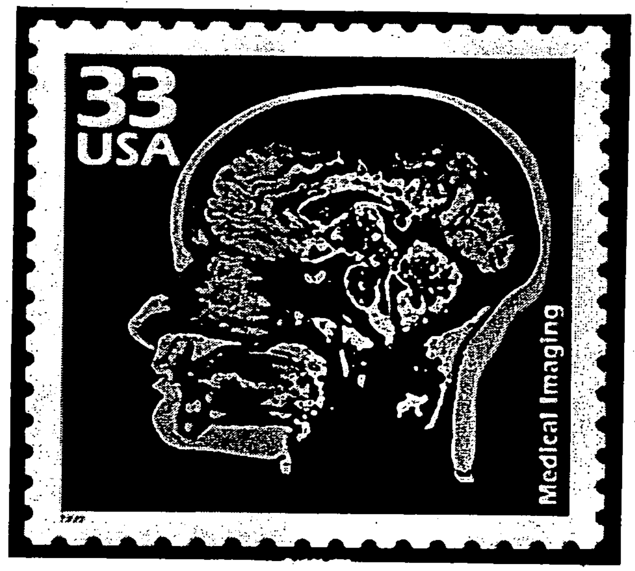
CH1\ 4520904.1

Medical imaging

From Wikipedia, the free encyclopedia.
(Redirected from Medical Imaging)

> It has been suggested that this article or section be merged into *Radiology*. (Discuss)

Medical imaging is the process by which physicians evaluate an area of the subject's body that is not externally visible. Medical imaging may be clinically motivated, seeking to diagnose and examine disease in specific human patients (*see* pathology). Alternatively, it may be used by researchers in order to understand processes in living organisms. Many of the techniques developed for medical imaging also have scientific and industrial applications.



Medical imaging often involves the solution of mathematical inverse problems. This means that cause (the properties of living tissue) is inferred from effect (the observed signal). In the case of ultrasonography the probe consists of ultrasonic pressure waves and echoes inside the tissue show the internal structure. In the case of radiography, the probe is X-ray radiation which is absorbed at different rates in different tissue types such as bone, muscle and fat.

Contents

Origins

In its most primitive form, imaging can refer to the physician simply feeling an area of the body in order to visualize the condition of internal organs. This was used historically to diagnose aortic aneurysms, fractures, enlarged internal organs, and many other conditions. It remains an important step today in making initial assessments of potential problems, although additional steps are often used to confirm a diagnosis. The primary drawbacks of this approach are that the interpretation may be quite subjective and that recording the 'image' is difficult.

Modern imaging technology

ATTACHMENT "A"

ładiographs

lain article: Radiography

.adiographs, more commonly known as x-rays, are often used to determine the type and extent of a fracture as well as for etecting pathological changes in the lungs. With the use of radio-opaque contrast media, such as barium, they can also be sed to visualize the structure of the stomach and intestines - this can help diagnose ulcers or certain types of colon ancer.

'luoroscopy

lain article: Fluoroscopy

'luoroscopy produces real-time images of internal structures of the body in a similar fashion to Radiography, but employs constant input of x rays. It is often used in image-guided procedures when constant feedback during a procedure is equired.

Computed tomography

Main article: Computed tomography

A CT scan, also known as a CAT scan (Computed Axial Tomography scan), traditionally produces a 2D image of the structures in a thin section of the body. It uses ionizing radiation such as X-rays and thus repeated scans should be avoided.

Magnetic resonance imaging

Main article: Magnetic resonance imaging

An MRI uses powerful magnets to excite hydrogen nuclei in water molecules in human tissue, producing a detectable signal. Like a CT scan, an MRI traditionally creates a 2D image of a thin "slice" of the body. As an MRI does not use ionizing radiation, it is the preferred imaging method for children and pregnant women.

Ultrasound

Main article: Medical ultrasonography

Medical ultrasonography uses high frequency sound waves of between 2.0 to 10.0 megahertz that are reflected by tissue to varying degrees to produce a 2D image, traditionally on a TV monitor. This is often used to visualize the fetus in pregnant women. Other important uses include imaging the abdominal organs, heart, male genitalia and the veins of the leg. While it may provide less anatomical information than techniques such as CT or MRI, it has several advantages which make it ideal as a first line test in numerous situations, in particular that it studies the function of moving structures in real-time. It is also very safe to use, as the patient is not exposed to radiation and the ultrasound does not appear to cause any adverse effects. It is also relatively cheap and quick to perform. Ultrasound scanners can be taken to critically ill patients in intensive care units saving the danger of moving the patient to the radiology department. The real time moving image obtained can be used to guide drainage and biopsy procedures. Doppler capabilities on modern scanners allow the blood flow in arteries and veins to be assessed.

Creation of three-dimensional images

Recently, techniques have been developed to enable CT, MRI and Ultrasound scanning software to produce 3D images for the physician. Traditionally CT and MRI scans produced 2D static output on film. To produce 3D images, many scans are made, then combined by computers to produce a 3D model, which can then be manipulated by the physician. 3D ultrasounds are produced using a somewhat similar technique.

With the ability to visualize important structures in great detail, 3D visualization methods are a valuable resource for the diagnosis and surgical treatment of many pathologies. It was a key resource (and also the cause of failure) for the famous, but ultimately unsuccessful attempt by Singaporean surgeons to separate Iranian twins Ladan and Laleh Bijani in 2003. The 3D equipment was used previously for similar operations with great success.

Other imaging techniques

Other proposed or developed medical imaging techniques (often termed *modalities*) include:

- diffuse optical tomography
- elastography
- electrical impedance tomography
- nuclear medicine
- optoacoustic imaging
- ophthalmology
  - A-scan
  - B-scan
  - corneal topography
  - Heidelberg retinal tomography
  - Optical coherence tomography
  - scanning laser ophthalmoscopy
- positron emission tomography

Some of these techniques are still at a research stage and not yet used in clinical routines.

Non-diagnostic imaging

Neuroimaging has also been used in experimental circumstances to allow people (especially disabled persons) to control outside devices, acting as a direct mind-computer interface.

External links

- Imaging-Centers.com (http://www.imaging-centers.com/) is the first searchable directory of medical imaging centers across the United States.

See also

- Medical test
- Medical examination
- PACS
- Tomogram
- Digital Imaging and Communications in Medicine (image format)
- Biomedical informatics

Retrieved from "http://en.wikipedia.org/wiki/Medical_imaging"

Categories: Articles to be merged | Medical imaging | Radiology | Image processing | Nuclear medicine

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ATTACHMENT "B"

On the cover: Photomicrograph of crystals of vitamin B_1.
(Dennis Kunkel, University of Hawaii)

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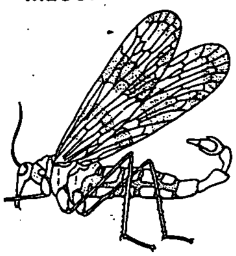
MECOPTERA



2 mm

orpion fly (*Panorpa*).

in the fetal intestine, becoming the first fecal discharge of the newborn. { mə'kō·nē·əm }

meconium ileus [MED] Intestinal obstruction in the newborn with cystic fibrosis due to trypsin deficiency. { mə'kō·nē·əm 'il·ē·əs }

Mecoptera [INV ZOO] The scorpion flies, a small order of insects; adults are distinguished by the peculiar prolongation of the head into a beak, which bears chewing mouthparts. { me'käp·tə·rə }

mecystasis [PHYSIO] Increase in muscle length with maintenance of the original degree of tension. { me'sis·tə·səs }

media [HISTOL] The middle, muscular layer in the wall of a vein, artery, or lymph vessel. { 'mē·dē·ə }

media conversion [COMPUT SCI] The transfer of data from one storage type (such as punched cards) to another storage type (such as magnetic tape). { 'mē·dē·ə kən,vər·zhən }

media conversion buffer [COMPUT SCI] Large storage area, such as a drum, on which data may be stored at low speed during nonexecution time, to be later transferred at high speed into core memory during execution time. { 'mē·dē·ə kən,vər·zhən ,bəf·ər }

mediad [ANAT] Toward the median line or plane of the body or of a part of the body. { 'mē·dē,ad }

medial [ANAT] **1.** Being internal as opposed to external (lateral). **2.** Toward the midline of the body. [SCI TECH] Located in the middle. { 'mē·dē·əl }

medial arteriosclerosis [MED] Calcification of the tunica media of small and medium-sized muscular arteries. Also known as medial calcinosis; Mönckeberg's arteriosclerosis. { 'mē·dē·əl ,är·tir·ē·ō·sklə'rō·səs }

medial calcinosis *See* medial arteriosclerosis. { 'mē·dē·əl ,kal·sə'nō·səs }

medial lemniscus [ANAT] A lemniscus arising in the nucleus gracilis and nucleus cuneatus of the brain, crossing immediately as internal arcuate fibers, and terminating in the posterolateral ventral nucleus of the thalamus. { 'mē·dē·əl lem'nis·kəs }

medial moraine [GEOL] **1.** An elongate moraine carried in or upon the middle of a glacier and parallel to its sides. **2.** A moraine formed by glacial abrasion of a rocky protuberance near the middle of a glacier. { 'mē·dē·əl mə'rān }

medial necrosis [MED] Death of cells in the tunica media of arteries. Also known as medionecrosis. { 'mē·dē·əl ne'krō·səs }

media migration [CHEM ENG] Carryover of fibers or other filter material by liquid effluent from a filter unit. { 'mē·dē·ə mī'grā·shən }

median [MATH] **1.** Any line in a triangle which joins a vertex to the midpoint of the opposite side. **2.** The line that joins the midpoints of the nonparallel sides of a trapezoid. Also known as midline. [SCI TECH] Located in the middle. [STAT] An average of a series of quantities or values; specifically, the quantity or value of that item which is so positioned in the series, when arranged in order of numerical quantity or value, that there are an equal number of items of greater magnitude and lesser magnitude. { 'mē·dē·ən }

median effective dose *See* effective dose 50. { 'mē·dē·ən i'fek·tiv 'dōs }

median infective dose *See* infective dose 50. { 'mē·dē·ən in'fek·tiv 'dōs }

median lethal dose *See* lethal dose 50. { 'mē·dē·ən 'lēth·əl 'dōs }

median lethal time [MICROBIO] The period of time required for 50% of a large group of organisms to die following a specific dose of an injurious agent, such as a drug or radiation. { 'mē·dē·ən 'lēth·əl ,tīm }

median mass [GEOL] A less disturbed structural block in the middle of an orogenic belt, bordered on both sides by orogenic structure, thrust away from it. Also known as betwixt mountains; Zwischengebirge. { 'mē·dē·ən 'mas }

median maxillary cyst [MED] Cystic dilation of embryonal inclusions in the incisive fossa or between the roots of the central incisors. Also known as nasopalatine cyst. { 'mē·dē·ən 'mak·sə,ler·ē ,sist }

median nasal process [EMBRYO] The region below the frontonasal sulcus between the olfactory sacs; forms the bridge and mobile septum of the nose and various parts of the upper jaw and lip. { 'mē·dē·ən 'nāz·əl ,prä·səs }

median nerve test [MED] A test for loss of function of the median nerve by having the patient abduct the thumb at right angles to the palm with fingertips in contact and forming a pyramid. { 'mē·dē·ən 'nərv ,test }

median particle diameter [GEOL] The middlemost particle diameter of a rock or sediment, larger than 50% of the diameter in the distribution and smaller than the other 50%. { 'mē·dē·ən 'pärd·ə·kəl dī,am·əd·ər }

median point [MATH] The point at which all three medians of a triangle intersect. { 'med·ē·ən ,pȯint }

median strip [CIV ENG] A paved or planted section dividing a highway into lanes according to direction of travel. { 'mē·dē·ən 'strip }

mediastinitis [MED] Inflammation of the mediastinum. { ,mē·dē,as·tə'nīd·əs }

mediastinum [ANAT] **1.** A partition separating adjacent parts. **2.** The space in the middle of the chest between the two pleurae. { ,mē·dē·ə'stī·nəm }

medical bacteriology [MED] A branch of medical microbiology that deals with the study of bacteria which affect human health, especially those which produce disease. { 'med·ə·kəl bak,tir·ē'äl·ə·jē }

medical chemical engineering [CHEM ENG] The application of chemical engineering to medicine, frequently involving mass transport and separation processes, especially at the molecular level. { 'med·ə·kəl 'kem·ə·kəl ,en·jə'nir·iŋ }

medical climatology [MED] The study of the relation between climate and disease. { 'med·ə·kəl ,klī·mə'täl·ə·jē }

medical electronics [ELECTR] A branch of electronics in which electronic instruments and equipment are used for such medical applications as diagnosis, therapy, research, anesthesia control, cardiac control, and surgery. { 'med·ə·kəl i,lek'trän·iks }

medical entomology [MED] The study of insects that are vectors for diseases and parasitic infestations in humans and domestic animals. { 'med·ə·kəl ,en·tə'mäl·ə·jē }

medical ethics [MED] Principles and moral values of proper medical conduct. { 'med·ə·kəl 'eth·iks }

medical examiner [MED] A professionally qualified physician duly authorized and charged by a governmental unit to determine facts concerning causes of death, particularly deaths not occurring under natural circumstances, and to testify thereto in courts of law. { 'med·ə·kəl ig'zam·ə·nər }

medical frequency bands [COMMUN] A collection of radio frequency bands allocated to medical equipment in the United States. { 'med·ə·kəl 'frē·kwən·sē ,banz }

medical genetics [GEN] A field of human genetics concerned with the relationship between heredity and disease. { 'med·ə·kəl jə'ned·iks }

medical geography [MED] The study of the relation between geographic factors and disease. { 'med·ə·kəl jē'äg·rə·fē }

medical history [MED] An account of a patient's past and present state of health obtained from the patient or relatives. { 'med·ə·kəl 'his·trē }

medical imaging [MED] The production of visual representations of body parts, tissues, or organs, for use in clinical diagnosis; encompasses x-ray methods, magnetic resonance imaging, single-photon-emission and positron-emission tomography, and ultrasound. { 'med·ə·kəl 'im·ij·iŋ }

medical microbiology [MED] The study of microorganisms which affect human health. { 'med·ə·kəl ¦mī·krō·bī'äl·ə·jē }

medical mycology [MED] A branch of medical microbiology that deals with fungi that are pathogenic to humans. { 'med·ə·kəl mī'käl·ə·jē }

medical parasitology [MED] A branch of medical microbiology which deals with the relationship between humans and those animals which live in or on them. { 'med·ə·kəl ,par·ə·sī'täl·ə·jē }

medical protozoology [MED] A branch of medical microbiology that deals with the study of Protozoa which are parasites of humans. { 'med·ə·kəl ,prō·dō·zō'äl·ə·jē }

medical radiography [MED] The use of x-rays to produce photographic images for visualizing internal anatomy as an aid in diagnosis. { 'med·ə·kəl ,rād·ē·'äg·rə·fē }

medication [MED] **1.** A medicinal substance. **2.** Treatment by or administration of a medicine. { ,med·ə'kā·shən }

medicinal [MED] Of, pertaining to, or having the nature of medicine. { mə'dis·ən·əl }

medicinal oil [MATER] A highly refined, colorless, tasteless and odorless petroleum oil used medicinally as an internal lu-

FOUNDATIONS OF MEDICAL IMAGING

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1

INTRODUCTION

The study of medical imaging is concerned with the interaction of all forms of radiation with tissue and the development of appropriate technology to extract clinically useful information from observations of this interaction. Such information is usually displayed in an image format. Medical images can be as simple as a projection or shadow image—as first produced by Röntgen nearly 100 years ago and utilized today as a simple chest X-ray—or as complicated as a computer reconstructed image—as produced by computerized tomography (CT) using X-rays or by magnetic resonance imaging (MRI) using intense magnetic fields.

Although, strictly speaking, medical imaging began in 1895 with Röntgen's discoveries of X-rays and of the ability of X-rays to visualize bones and other structures within the living body [1], contemporary medical imaging began in the 1970s with the advent of computerized tomography [2, 3]. Early, or what we call *classical*, medical imaging utilizes images that are a direct manifestation of the interaction of some form of radiation with tissue. Three examples will illustrate what we mean by classical imaging. First is the conventional X-ray procedure in which a beam of X-rays is directed through the patient onto a film. The developed film provides a shadow image of the patient which is a direct representation of the passage of X-rays through the body. Although such images are not quantitative, they do provide some measure of the attenuation of X-rays in tissue. Thus a section of soft tissue will appear darker than an equally thick section of bone, which attenuates more of the X-rays. It should be noted that even with current technological developments

conventional X-ray imaging still represents the major imaging procedure at most medical facilities.

As a second example of classical imaging, consider a conventional nuclear medicine procedure. Here a radioactive material is injected into the patient and its course followed by a detector which is moved over the patient in a specified manner. Although the image recorded by the detector generally has poor spatial resolution, its real advantage is that it provides a measure of physiological function from the time course of the radioisotope uptake. Clearly the conventional nuclear medicine image is a direct measure of the location and concentration of the radioactive isotope used.

As a final example of classical imaging, consider conventional medical ultrasound. Here, a pulse of ultrasonic energy is propagated into the patient and the backscattered echo signal is recorded by the same transducer. By angulating or moving the transducer (or by using a transducer array) positionally sequential echo signals are recorded, and a cross-sectional image of the subject is displayed directly on a video monitor. Ultrasound images are really a mapping of echo intensities and are a direct result of the interaction of the ultrasound pulse with tissue.

In this text we will define modern or contemporary medical imaging operationally as a two-part process: (1) the collection of data concerning the interaction of some form of radiation with tissue, and (2) the transformation of these data into an image (or a set of images) using specific mathematical methods and computational tools. Note that our definitions for both classical and modern imaging are consistent with our general definition of medical imaging, given in the first paragraph of this chapter. Note also that modern imaging can be represented as a generalization of classical imaging and that classical imaging is simply a special case of modern imaging in which the image forms directly from the interaction process. Whereas classical imaging is direct and intuitive, modern imaging is indirect and, in many cases, counter intuitive. Since modern images are formed by processing, reformulating, or reconstructing an image from the tissue/radiation interaction data base, the process is often referred to as "reconstruction" and the image as a "reconstructed image."

The first device capable of producing true reconstructed images was developed by G. N. Hounsfield [2] in 1972 at EMI in England. Hounsfield's X-ray computerized tomograph device was based in part on mathematical methods developed by A. M. Cormack [4] a decade earlier. For their efforts Hounsfield and Cormack were awarded the Nobel Prize in medicine in 1979. Put quite simply, CT imaging is based on the mathematical formalism that states that if an object is viewed from a number of different angles, then a cross-sectional image of it can be computed (or "reconstructed"). Thus X-ray CT yields an image that is essentially a mapping of X-ray attenuation or tissue density.

The introduction of X-ray CT in 1972 represents the real beginning of modern imaging and has altered forever our concept of imaging as merely

Table 1-1 3-D image reconstruction algorithms

2-D and 3-D Projection Reconstruction	2-D Projection Reconstruction	Parallel-Beam Mode
		Fan-Beam Mode
	3-D Projection Reconstruction	Parallel-Beam Mode
		Cone-Beam Mode
Iterative Method	Algebraic Reconstruction Technique (ART)	
	Maximum Likelihood Reconstruction (MLR) or Expectation Maximization (EM) Reconstruction	
Fourier Reconstruction	Direct Fourier Reconstruction (DFR)	
	Direct Fourier Imaging (DFI) in NMR	

taking a picture. It has also led to the development of 3-D imaging and is making quantitative imaging a reality. The application of reconstructive tomography to conventional nuclear medicine imaging has led to the development of two new imaging modalities: single photon emission computed tomography (SPECT) and positron emission tomography (PET). Similar applications to the laboratory technique of nuclear magnetic resonance (NMR) has led to magnetic resonance imaging (MRI). The CT concept is currently being extended to 3-D magnetoencephalography, electrical impedance tomography, and photon migration tomography, to name a few. Inherent to the development of these new imaging modalities has been the development of new reconstruction techniques, which are detailed in Table 1-1.

In this chapter we seek to provide a brief historical perspective for the various medical imaging modalities that are currently important. The various techniques are shown in Figs. 1-1 and 1-2 where they are characterized by the interrogation wavelengths. A parallel sequence will be followed in the succeeding chapters which provide more detailed discussions of the various imaging modalities. Although the various imaging techniques will, of necessity, be treated separately, our goal is to provide a unified approach to the field of medical imaging.

1-1 THE BEGINNING WITH X-RAYS

The history of medical imaging really began on November 8, 1895, when Wilhelm Konrad Röntgen reported the discovery of what he called "a new

Principles of Medical Imaging

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ATTACHMENT "D"

Cover photograph courtesy of Michael B. Smith. A computer model of the human head showing the naturally occuring magnetic field gradients found in all normal humans when exposed to a homogeneous, static magnetic field of 1 tesla. Each contour line describes a field change of 0.3 parts per million. The differences in the magnetic field are due to the magnetic susceptibility of the air–tissue interface associated with the sinus cavities in the head.

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Preface

The field of medical imaging is growing at a rapid pace. Since the early 1960s, three new imaging modalities, namely, radionuclide imaging, ultrasound, and magnetic resonance imaging, have appeared and matured. Along with X-ray they are among the most important clinical diagnostic tools in medicine today. Radionuclide imaging, although its resolution cannot match that of other modalities, uses radioactive isotopes attached to biochemically active substances to yield unique information about the biochemical or physiological function of the organ which is unattainable otherwise. Ultrasound scanners use high frequency sound waves to interrogate the interior of the body. They are capable of depicting anatomical details with excellent resolution. Ultrasound is particulary suited to situations where exposure to ionizing radiation is undesirable, such as in obstetrical and neonatal scanning, and to imaging structures in motion, such as heart valves. Magnetic resonance imaging, however, has been envisioned to be the most exciting of them all by far because it also uses a form of nonionizing radiation, can achieve superior resolution, and is capable of yielding physiological information. In this period, significant progress has also been achieved in conventional X-ray radiography. Improved design or introduction of better materials in image intensifiers, intensifying and fluoroscopic screens, and photographic films has enhanced the resolution to a significant degree without adding higher patient radiation exposure levels. It is therefore plausible to understand why conventional radiography is still routinely used clinically for the diagnosis of many diseases and is the gold standard to which newer imaging modalities are compared.

Unquestionably, the digital revolution is the primary reason that has caused the medical imaging field to experience the explosive growth that we are seeing today. Computer and digital technology along with advances in electronics have made data acquisition fast and mass data storage possible. These are the most essential ingredients for the practical realization of tomographical reconstruction principles. X-ray computed tomography (CT), digital radiography, real-time ultrasonic scanners, single-photon emission computed tomography (SPECT), positron emission tomography (PET), and magnetic resonance imaging (MRI), which came about after the early 1970s, are just a few well-known products of the digital revolution in medical imaging.

While the development of these new imaging approaches may have contributed greatly to the improvement of health care, it has also contributed to the rising cost of health care. A chest X-ray costs only $20–30 per procedure whereas a magnetic resonance scan may cost up to $1000, let alone the expenses associated with acquiring and installing such a scanner. The cost-to-benefit ratio for

these expensive procedures in certain cases is sometimes not as clear as in others. Therefore it is not unusual that the clinical efficacy and contribution of these modalities to patient care are being scrutinized and debated constantly by the medical community as well as the public.

This book is intended to be a university textbook for a senior or first-year graduate level course in medical imaging offered in a biomedical engineering, electrical engineering, medical physics, or radiological sciences department. Much of the material is calculus based. However, an attempt has been made to minimize mathematical derivation and to place more emphasis on physical concepts. A major part of this book was derived from notes used by the authors to teach a graduate course in medical imaging at the Bioengineering Program of Pennsylvania State University since the late 1970s. This book covers all four major medical imaging modalities, namely, X-ray including CT and digital radiography, ultrasound, radionuclide imaging including SPECT and PET, and magnetic resonance imaging. It is divided into four chapters in which a similar format is used. In each chapter fundamental physics involved in a modality is given first, followed by a discussion on instrumentation. Then various diagnostic procedures are described. Finally, recent developments and biological effects of each modality are discussed. At the end of each chapter a list of relevant references, further reading materials, and a set of problems are given. The purpose of this textbook is to give students with an adequate background in mathematics and physics an introduction to the field of diagnostic imaging; the materials discussed should be more than sufficient for one semester. However, the book may also be used as the text for a two-semester course in medical imaging when supplemented by additional materials or by inclusion of more mathematic detail.

Although this book has been written as a college textbook, radiologists with some technical background and practicing engineers or physicists working in imaging industries should also find it a valuable reference in the medical imaging field. As a final note, it should be pointed out that there are other imaging methods that have been used in medicine [e.g., thermography, magnetic imaging, and microwave imaging (Hendee, 1991)]. They are not included in this book primarily due to their limited utility at present. Readers who are interested in these modalities may refer to several books listed in the following reference section.

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